

CHAPTER 1

INTRODUCTION

1.1 GENERAL

The greatest impact of the industrial revolution on people's life is the manufacture of automobiles. Motorization has brought unprecedented mobility, and an extremely convenient form of transport for men and goods, while creating new opportunities for employment. One of the important sources of air pollution is the vehicular exhaust emission. Study of emissions from automobiles, their transport and transformation at the urban scale is a complex task. Air pollution is a serious public health problem in most of the metropolitan areas around the world. Vehicles with poor quality emission and poor maintenance are significant contributors to air pollution in cities. Air Pollutants are fine particles and gaseous contaminants that are let into the atmosphere from various sources. These air pollutants cause physiological responses in organisms, and a wide range of health effects in humans. Among the various sources contributing to air pollution, the automobiles have emerged as the largest source of urban air pollution. Due to versatility, flexibility and low initial costs, there has been a boom in the manufacturing and usage of different types of vehicles. This has resulted in deterioration of air quality (Longhurst et al. 2000).

Most of the cities suffer from serious outdoor air pollution due to improper maintenance of vehicles (Ravindra 2003). The increased demand of vehicles has increased the emission of air pollutants into the atmosphere (Tecer 2008). Such activities cannot be stopped as they are directly related to the development of the society. This type of development and urbanization



brings with them the unwanted air pollutants, namely, Suspended Particulate Matter measured as PM_{10} and $PM_{2.5}$, Sulphur dioxide (SO_2), Oxides of Nitrogen (NO_x), etc.

1.2 SOURCES OF AIR POLLUTION

Air pollution sources are classified into two types. They are, Natural and Anthropogenic sources.

1.2.1 Natural sources

1.2.1.1 Dust storm

Dust storms are produced due to wind circulation around the earth, generally in deserts. The global meteorological process makes the environment dust polluted, in some areas and on some occasions.

1.2.1.2 Forest fire

Huge quantities of smoke are emitted during forest fire.

1.2.1.3 Volcanoes

Volcanoes release lot of solid particles, gases like Sulphur dioxide and radiation. Heat waves may spread up to several kilometers. The surrounding areas are greatly affected with heavy dust and thermal pollution.

1.2.1.4 Sea spray

Sea spray is a continuous phenomenon and a major source of particulate (liquid droplets) pollution in the atmosphere.



1.2.1.5 Plant pollen

During the spring season, lot of plant pollen is produced and due to wind motion, it spreads very fast which makes the atmosphere dust polluted.

1.2.2 Anthropogenic Sources

1.2.2.1 Domestic pollution

Domestic air pollution is generated by the domestic or household activities like cooking or use of insecticides for cleaning and maintenance of houses. Even though it is not significant comparing with other sources, it contributes to ill - health of the human beings. Good housekeeping methods may help to reduce the pollution.

1.2.2.2 Industrial pollution

Many industries have chimneys. Among the industries, smoke from thermal power plants, chemical plants, cement plants, paper mills, textile mills and steel industries pollute the atmosphere. Adopting proper pollution control methods will help to reduce pollution in these sources.

1.2.2.3 Traffic pollution

Exhaust from vehicles and airborne suspension of dust due to vehicle movements cause air pollution. It is considered as serious as industrial pollution because of rapid and unplanned urbanization. The pollution produced by traffic may be in the form of exhaust gases, particulates and noise. This pollution may be minimized by the use of good fuels and through effective utilization of pollution control technology.



1.3 Major Air Pollutants

1.3.1 Suspended Particulate Matter

Suspended Particulate Matter is finely divided into solids or liquids that may be dispersed through the air by natural or artificial processes.

1.3.1.1 PM₁₀

Airborne Particulate Matter (PM) includes coarse and fine particles such as dust, dirt, soot, smoke and liquid droplets emitted into the air. They are small enough to get freely suspended in the atmosphere, and can travel over longer distances through air. PM₁₀, by definition has a diameter of 10 µm or less.

1.3.1.2 PM_{2.5}

PM_{2.5} is particle material below 2.5 µm diameter. PM_{2.5} is composed of a mixture of primary and secondary particles. Major sources of the PM_{2.5} pollutants are emitted from fossil fuel combustion by electric utilities, industry, motor vehicles, vegetative burning and smelting or other processing of metals.

1.3.1.3 Sulphur dioxide (SO₂)

SO₂ is a colourless gas, non-flammable and non-explosive. SO₂ has a suffocating odour. SO₂ is the second most important air pollutant. The burning of fossil fuel in thermal power plants, smelting industries and other processes like electric power plants produce SO₂.



1.3.1.4 Oxides of nitrogen (NO_x)

The stable gaseous oxides of nitrogen include N₂O, NO, N₂O₃, N₂O₄, NO₂ and N₂O₅. Of these, N₂O, NO and NO₂ are present in a significant amount and are potential contributors to air pollution. N₂O is an inert gas with unaesthetic characteristics. NO₂ is a reddish brown gas. N₂O is a colourless gas and is an active compound in photochemical formation.

1.3.1.5 Carbon monoxide (CO)

Carbon monoxide is a colourless gas. CO is chemically inert under normal conditions. CO reacts with haemoglobin (Hb) of blood to give carboxyhaemoglobin (COHb). This reduces the capability of blood to carry oxygen. Carbon monoxide is produced from the partial oxidation of carbon containing compounds. It is formed where there is not enough oxygen to produce carbon dioxide. When a complex is on fire, the CO is produced. Similarly CO is produced in internal combustion engine, volcanoes, forest fires and other forms of combustion.

1.3.1.6 Ozone (O₃)

Ozone (O₃) is a colourless, poisonous gas with a sharp, cold and irritating odour. Ozone is formed in the troposphere as a result of anthropogenic emissions. The process of ozone formation may take several days to complete. Ozone is a photochemical oxidant and is produced in the upper atmosphere by solar radiation. Also, small concentrations of ozone are produced by lightning and forest fires. Ozone is usually accumulated in the upper strata of atmosphere at around 25-40 km range from earth and is known as “Ozone blanket” or “Ozone layer”. It does not allow the dangerous incoming UV rays. Life on earth is probably possible only due to this protective umbrella of ozone.



1.3.1.7 Ammonia (NH₃)

Ammonia is a colourless, pungent and hazardous caustic gas composed of nitrogen and hydrogen. Ammonia emissions are also grouped as NH_y which is a sum of NH₃ and NH₄. The major sources of ammonia emissions is agriculture. Livestock farming and animal waste account for the biggest percentage of total ammonia emissions.

1.4 GLOBAL EFFECTS OF AIR POLLUTION

The air pollutant affects the living and non-living things at the global level. The global effects of air pollution are as follows:-

1.4.1 Effects on Human

Under natural biological conditions, breathing is not at all hazardous, provided the air is of proper and uniform composition. All particles, smaller than 10 microns in diameter, can reach the human lungs, their retention time is the largest for the finer particles. Products of incomplete combustion can enter deep into the lungs.

The effects of inhaling particulate matter include asthma, lung cancer, cardiovascular issues and premature death. Air pollution causes eye irritation, and the sharpness of vision is reduced. Air pollution affects the respiratory system of human beings. They also cause visibility reduction.

1.4.2 Effects on Materials

Particulate matter can damage materials by soiling textiles, corroding metals, eroding building surfaces, discolouring and destroying paint surfaces.



1.4.3 Effects on Plants

The dust coating on leaves reduces photosynthesis and the increased plugging of stomata reduces plant growth. Ammonia has caused serious damage to vegetation, as a result of accidental spills, that allowed high concentrations of the gas to be carried by the winds over vegetation in the vicinity. Ammonia injury causes acute tissue collapse, with or without chlorosis.

1.4.4 Effects on Climate and Weather

CO₂, water vapour, methane, N₂O, ozone and CFC are green house gases. The green house gases allow the incoming solar radiation to pass through, but do not allow the reradiation from earth to space to pass through. This is called 'Green House Effect'.

Impact of Green House Effect on environment is Global Warming. Due to this, the mean ambient air temperature is expected to increase at an alarming rate about 0.5 to 1° C per decade.

The Oxides of nitrogen and sulphur undergo transformation in the atmosphere and form nitrates, sulfates, nitric acid or sulfuric acid droplets. Some of these pollutants, especially the oxides of sulphur, can travel 200 – 300 kms in a day. Thus, the compounds emitted at a place may be carried hundreds of kilometers by the wind and deposited on ground or on vegetation directly as 'ACID RAIN'.



If pH of rain is less than 5.6, it is termed as 'acid rain'.



Earth has a protective umbrella in the form of Ozone layer, a 24 km thickness in the stratosphere about 15 km away from earth's surface. The discharge of anthropogenic air pollutants such as CFCs, the chlorofluoro carbons, into the atmosphere, destroy the stratosphere ozone, as a result of which the ozone layer is thinned. The patches of thinned ozone layer are known as "Ozone Holes".

1.5 AUTOMOBILE EXHAUST POLLUTION IN INDIA

In most of the metropolitan areas of the world, transportation facilities are improving every year in order to meet the increased demand. As a result, more and more vehicles are added to the roadways. Vehicular traffic has become a major source of air pollution in urban areas.

The rapid growth of motor vehicles ownership, and activities in Indian cities, are causing serious health, environmental and socio-economic impacts (Badami 2009). The rapidly growing vehicle fleet, distance travelled by each vehicle and change in land use pattern are some of the primary causes of vehicular air pollution, and consequently the urban air pollution. (Mayer 1999).

In India, the motor vehicle population has increased from nearly 0.3 million in 1951 to 115 million in 2009, of which two wheelers accounts for approximately 70% of the total vehicles (CPCB 2010). Two wheelers, combined with cars, account for approximately 80% of the total vehicles.

Vehicular emission is the major contributor to urban air pollution in most of the cities in India and estimated to account for 70% of CO, 50% of HC, 30% to 40% of NO_x, 30% of SPM and 10 % of SO₂ of the total pollution load. Two - third is contributed by two wheelers alone (Sharma et al. 2005).



In India, specifically in Delhi, vehicular emissions contributes 67% of the total air pollution load, which is approximately 3,000 metric tons per day. The results of air analysis must be made known to the public to protect the society from injury and the products from contamination. Hence, determination of pollution level in the atmosphere is important in a toxicological perspective.

Average values of PM_{10} and $PM_{2.5}$ concentrations have been found to be $26 \mu\text{g}/\text{m}^3$ and $18 \mu\text{g}/\text{m}^3$ under ambient conditions in the city of Hyderabad during the year 2003 (Latha 2005). Vehicular emissions are a prime source of Polycyclic Aromatic Hydrocarbons (PAH) and heavy metals. Other traffic related heavy metal pollutants include Fe, Zn, Cu, Cr, Pb, Cd, Ni, Mn and CO (Omar Ali Al-Khashman 2007).

Previous studies in Coimbatore city, on seasonal variation of suspended particulate matter with reference to wind direction, show that, the SPM concentration is found to be more during January to March, due to high humidity and low wind velocity (Tandon 2008). The elemental composition analysis of ambient air sample of Coimbatore has revealed the presence of heavy metals concentration, associated with respirable and non-respirable fractions of suspended particulate matter. The concentration of heavy metals found in the ambient air are in the following order : Zinc > Copper > Lead > Nickel > Cadmium (Mohanraj 2004). Seasonal variations of PM_{10} and $PM_{2.5}$ have been observed to be maximum during winter and minimum during monsoon.

1.6 AIR POLLUTANTS AND THEIR IMPACT

Most of the cities in Northern India are affected due to the presence of unusually high concentration of PM_{10} in the ambient air, posing a



serious risk to human health (Tandon 2008). The increased air pollutant concentrations in urban area are responsible for the malfunctioning of the pulmonary system, cardiovascular disease and neuro-behavioural effects.

Particulate air pollution was one of the pollutants demonstrated to have serious short-term health effects, even at low ambient levels, when absorbed into human lungs. The issue of urban air quality is receiving increasing attention, as a growing share of the world's population is now living in urban centres, and demanding a cleaner urban environment (Gurjar 2008). According to the United Nations report (UN 2003) the global urban population continues to grow faster than the total population of the world. Population and economic growth have often been a serious concern for the environmental deterioration on the surrounding areas (Reddy 2001). India has experienced substantial increase in Vehicle Miles Travelled (VMT) in recent years. The increased traffic has resulted in increased pollutant emissions and the deterioration of air quality and human health in several major cities in India.

1.7 COIMBATORE CITY

Coimbatore, popularly known as the Manchester of South India, is situated at 11° North latitude, 77° East longitude and 432.5 metres above Mean Sea Level in the western part of Tamil Nadu. It is situated at the foot of Nilgiri hills. Hence, it enjoys a salubrious climate throughout the year. The maximum temperature observed in this city is 35° C and the minimum temperature around 18° C. April and May are the hottest months in this city. This city has an annual average rainfall of 70 centimeters. This city is the second largest city in Tamil Nadu, covering an area of 23.5 square kilometers with more than 30,000 small, medium, large-scale industries and textile mills.



The present population of the city is 20 lakhs with a floating population of around 1.5 lakhs.

Coimbatore city and its environs with a population of 19,90,000 occupies the 206th position among the principal urban agglomerations of the world as on 2014 (<http://www.citypopulation.de/world/Agglomerations.html>). Coimbatore city is one of the top ten fastest growing cities of India, and is among the top 100 in the world. There are about 20,000 small-scale industries functioning in and around the city. The number of medium and large scale textile mills present in Coimbatore is 312. In the wake of urbanization and industrialization, the number of automobiles is also rising at a similar pace. Among the sources of air pollution, vehicular emissions, industrial emissions and smoke, arising from the garbage dump, are prominent in the city.

Coimbatore city in the State of Tamil Nadu is among the rapidly-growing Indian cities facing serious air quality problems due to vehicular air pollution. Specifically, pollutant concentrations near major intersections and roadways may exceed the Indian National Ambient Air Quality Standards (NAAQS). Thus, users (residents, pedestrians, motorists, etc.) in these corridors are exposed to unhealthy pollution levels. Exposure to vehicular air pollution directly affects the respiratory, nervous and cardiovascular systems of humans, resulting in impaired pulmonary functions and sickness. (Hall 1996).

1.8 SIGNIFICANCE OF STUDY

The total number of vehicles registered in Coimbatore city as in 2010 exceeded 1 million. Over the period of five years ending in 2006, 23 metros posted a compound annual growth rate of 8.3% in the number of



total vehicle registrations. Significantly, among the second-tier cities, Coimbatore with 12.9% growth rate stood first in Tamil Nadu state, India, followed by Madurai city (10.9%) (Ministry of Shipping, 2009). Coimbatore holds a share of 0.84% and 7.46% of the total registered motor vehicles in India and Tamil Nadu, respectively. Gradual growth in goods vehicle category hints an economic shift from commodity-producing sector (agriculture and industry) towards service sector. High growth in personalized motor vehicles, reflects rising per capita income of middle class market competition, in automobile sector due to globalization coupled with convenient financing options. This proliferation in the personalized mode of transport has evidently increased traffic congestion and air pollution. Because of the prevailing weather condition, topography and growth pattern, this city has a high potential for air pollution.

1.9 OBJECTIVES OF THE STUDY

It was proposed to monitor ambient air quality of Coimbatore city, by conducting ambient air quality survey at important road junctions. 6 such busy road junctions were selected, and it was proposed to conduct monitoring near the selected road junctions.

The main objectives of this study are:

1. To conduct ambient air quality monitoring to monitor parameters such as PM_{10} , $PM_{2.5}$, SO_2 , NO_x , CO , O_3 and NH_3 near all the 6 busy road junctions in Coimbatore city during the period from January 2011 to December 2012,
2. To observe meteorological parameters during the period from January 2011 to December 2012 in the study area,



3. To carry out traffic survey in 6 busy road junctions in Coimbatore city, during the period from January 2011 to December 2012,
4. To simulate the dispersion pattern of CO near busy road junctions using CALINE-4 Model, and
5. To forecast the concentration of CO near busy road junctions using Artificial Neural Network (ANN).

